Saskatchewan Agriculture, Food and Rural Revitalization

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

19980309

CHARACTERIZATION AND EVALUATION OF OAT GERMPLASM FOR INCREASED UTILIZATION

Funded by:
The Agriculture Development Fund

October 2003
Prepared by: Agriculture & Agri-Food Canada

104-02328/

Final Report for the project:

Characterization and evaluation of oat germplasm for increased utilization.

(ADF Project No. 98000309)

Submitted to the

Saskatchewan Department of Agriculture and Food

by

Dr. Axel Diederichsen, Principal Investigator
Plant Gene Resources of Canada, Agriculture and Agri-Food Canada,

Saskatoon, Saskatchewan

December 2002

1. Abstract

The objective of this project was to characterize and evaluate, using morphologic, agronomic, disease resistance and quality characters, the genetic variability among available oat accessions in the Plant Genetic Resources of Canada (PGRC) collection of cultivated oat and related wild species of the genus *Avena* L. The generated data will be placed into the Genetic Resources Information Network-Canadian Version (GRIN-CA) on the Internet (http://www.agr.gc.ca/pgrc-rpc). With about 27,000 accessions, PGRC maintains the world's largest collection of oat germplasm. In particular, the collection of wild species of the genus *Avena* is unique in the world since Canadian scientists collected about 7,000 accessions at native sites. These accessions are part of the PGRC collection. The recent regeneration of 10,991 *A. sativa* accessions and 2,825 accessions of other *Avena* species and the characterization data collected on these accessions allows plant breeders and other scientists to make efficient use of the germplasm in the PGRC collection. The characterization effort delivers information about performance of the diverse germplasm under Western Canadian conditions, which makes this information particularly valuable to Canadian plant breeders. The regenerations during the last four years produced seeds of high quality which ensures long term preservation of diversity within the genus *Avena*. As a result of this project, availability of this germplasm is ensured and PGRC can respond positively to seed requests.

2. Executive Summary

In 2001, Canadian farmers harvested about 1.16 Million hectares of oat. During the last five years a slight decrease in the area planted to oat occured. About 40% of the oat production is exported. About 90% of Canadian oat production occurs in the Prairie Provinces (Statistics Canada 2002). Presently, there are six oat-breeding programmes in Canada: Lacombe, Alberta; Saskatoon, Saskatchewan; Winnipeg, Manitoba; Guelph, Ontario; Ottawa, Ontario; and Montreal, Quebec. There are currently 60 hulled and 12 hull-less oat cultivars registered in Canada (CFI 2002). The importance of acquiring additional genetic resources for oat breeding was recognized early by Canadian plant breeders and scientists. In 1964, the first collection mission by Canadian scientists to collect wild and cultivated oat in the Mediterranean area was conducted. These collecting activities continued until the middle of the 1970's, when more than 7,000 accessions of oat germplasm were brought back to Canada and now form part of the PGRC oat collection. The Mediterranean species *A. barbata* and, in particular, the hexaploid *A. sterilis* have frequently been used as donors for resistance genes to plant diseases. More than 30 crown rust genes have been identified in *A. sterilis* and used in oat breeding programmes.

In the late 1970's, changes in the genetic composition of the pathogen populations of rust diseases caused severe production losses for the oat farmers in Manitoba. Introducing new resistance genes into cultivated oat solved these problems. Presently, crown rust (*Puccinia coronata* Cda. f. sp. *avenae* Eriks), stem rust (*P. gramminis* Pers. f. sp. *avenae* Eriks.) and smuts [*Ustilago avenae* (Pers.) Rostrup. and *Ustilago kolleri* Wille] are efficiently controlled by resistance breeding. However, the pathogen population changes and breeding has to respond to these ongoing changes. The two rust diseases are particularly critical in the three Prairie Provinces. Recently a new virulent race of stem rust has occurred and screening of available genetic resources is necessary (T. Fetch, Winnipeg Cereal Research Centre, pers. communication). Intense screenings are conducted at the Cereal Research Centre Winnipeg Agriculture and Agri-Food Canada to observe the pathogen populations and identify new resistance genes in the available germplasm.

Concerns have arisen among oat breeders that the genetic base of breeding materials available for further development of cultivars has been greatly reduced through long-term and extensive breeding efforts with genetically similar pedigrees. When genetic diversity decreases, vulnerability to pests, diseases, and adverse abiotic factors increases. Introduction of new germplasm to current oat breeding programs is urgently needed.

In 1995, responsibility for Plant Gene Resources of Canada (PGRC), the national seed genebank, was transferred to the Saskatoon Research Centre. In 1998, the national oat collection was physically moved into the new facility in Saskatoon to rejuvenate, document, collect and preserve seed stocks of cultivated plants and their wild relatives as a resource for genetic improvement of crops by Canadian plant breeders. Up to now, the collection has neither been actively documented nor rejuvenated. There is a need for Canadian researchers to have access to a diversified genetic resource base to assure sustainability and competitiveness of agriculture for future generations.

3. Technical report

3.1 Composition of the collection

An overview of the different species of the genus *Avena* in the PGRC collection is presented in Table 1. This table compares the composition of the two largest oat germplasm collections in the world, which are held by PGRC and the United States National Plant Germplasm System (NPGS), respectively. Cultivated oat (*Avena sativa*) and the wild, hexaploid species *Avena sterilis* both are represented by more than 11,000 accessions in the PGRC genebank and are the dominant species in the collection. The collection of *A. sativa* is to a large extent a duplication of the collection held in the United States NPGS (Table 2). The geographical origin of the *A. sativa* accessions in the PGRC collection with completed characterization indicates samples from all over the world (Table 2). About 7,000 accessions of *Avena sterilis* in the PGRC collection are also duplicated in the USDA collection and were collected from Israel. However, in the USA, *Avena sterilis* and other wild *Avena* species have limited regeneration because some of these species are considered noxious weeds and any work with them is very restricted. As a result, access to this material in the USA is difficult and preservation of the Canadian collection has great impact on the utilization of this germplasm. Canadian scientists have collected the other accessions of *A. sterilis* and PGRC is keeper of the base collection of these accessions. The majority of the PGRC oat accessions are hexaploids, and this group is most important as a genetic resource for oat breeding because the genetic transfer of traits is technically not as difficult as for species of a different ploidy level.

3.2 Regeneration of the collection

All oat species considered here are self-pollinating plants. Therefore, no particular means for isolation to avoid cross-pollination are required. Regeneration was conducted in greenhouses, if there were low amounts of seeds (wild oats and cultivated oat) or if the species requirements did not allow field regeneration (many wild oat species). Growing the wild *Avena* species in the field is problematic in Saskatchewan due to the short growing season and the spontaneous seed-shattering, which makes it necessary to bag panicles the prior to maturity. A summarized list of the *Avena* regeneration during the course of this project is given in Table 3. The total number of PGRC accessions planted for regeneration during the project was 17,724. The regeneration of cultivated oat is technically easier to handle since this oat is well adapted to the growing conditions at Saskatoon. Therefore, the total amount of cultivated hexaploid oat accessions planted was much larger (13,741 accessions) than the amount of other oat species (3,983

accessions). Greenhouse capacity affiliated to PGRC limited the number of oat planted to 1,372 accessions of wild oat species and 504 accessions of cultivated oat in this controlled environment.

In the field, cultivated oat was planted using 7 g of seed in single rows of 3 m length. The effective distance between the oat rows was 60 cm, the oat rows were planting alternating with winter wheat. This procedure reduced the possibility of technical seed mixture. The Canadian oat cultivars 'AC Assinaboia' and 'CDC Pacer' were planted alternating every 40 rows and used as checks for data standardization in quantitative characters. The standardization was conducted by calculating the mean value for the check cultivars in each block of oat and considering this value as 100% for the respective character. The observations for quantitative characters made on other accessions were compared to these means and reported as percent of the checks. The cultivated oat accessions grown by the Crop Development Centre (1,000 accessions in 2000 an 2001) were planted in hills using 15 seeds; the cultivars 'AC Assinaboia', 'AC Juniper' and 'Derby' were planted every 56 hills as checks.

When regenerating the wild oat species, 40 seeds were planted in the field rows of 1m length with a distance of 1m between the rows. In 2000 and 2001 winter wheat was grown between the oat rows, which was discontinued in 20002, because the wheat competed too much for water with the oat plants. Sunflowers were grown in four or more rows surrounding the wild oat blocks to prevent wind damage. Prior to maturity, the oat panicles were bagged to avoid seed losses due to shattering.

In the greenhouse, depending on the amount of seeds available, 1-8 seeds of *A. sativa* or the other oat species were planted in up to ten 6" pots with soil-less mix. Wild oat panicles were bagged prior to maturity.

In cultivate oat a regeneration cycle was considered successful, if it produced at least 100 g of seed. For the 11,768 accessions grown until 2002, this goal was reached for 9331 accessions (79.3%). The remaining 20% were either dead (572 accessions), or duplicates (405 accessions), or were re-grown in 2002. The increase of 2002 is still in the process of characterizing the seeds and measuring seed weights, there is a small number of accessions that will need to be planted once more in 2003 to reach the goal of 100 g of seed per accession.

In the wild oat species field regeneration concentrated on the hexaploid species *A. sterilis* and *A. fatua*, while the other oat species require a longer growing season and had to be grown in the greenhouse. There is still a large amount of germplasm of wild oat germplasm left in the PGRC collection which is in urgent need of regeneration.

As a result of this project 10,991 *A. sativa* accessions, which is nearly the complete collection of this species, was regenerated. The seeds are stored for long term preservation at -18°C and germplasm is available for distribution. This project made it possible to successfully increase 2,825 accessions of other oat species, with emphasis on the hexaploid wild oat species, which are the most important source for genetic improvement of cultivated oat in this group.

3.3 Characterization

A detailed descriptor list for the germplasm of cultivated and wild oat was developed in consultation with Canadian oat breeders and international genebanks maintaining oat collections (Russia, Germany, USA). The characters on this list are used for describing the diversity of the PGRC collection using morphological and agronomic characters. This information allows

breeders to search the collection for certain traits and to identify infraspecific groups within the collection of cultivated oats. For the wild species such characterization is needed for determination of the botanical species. The activities regarding characterization are all controlled by PGRC at Saskatoon. Special emphasis is given to this activity to ensure the taxonomic correctness of the species information in the collection and to have basic information about each accession available to users of the collection. All characterization data will be made available via the internet at the PGRC website (http://www.agr.gc.ca/pgrc-rpc). A summarizing discussion of the phenotypic diversity within the PGRC *A. sativa* collection is presented in the following paragraphs. The Tables 4-6 in the appendix give a detailed account of the characterization effort in *A. sativa*; in total, more than 170,000 single observations on germplasm of this species are documented.

3.3.1 Phenotypic diversity in cultivated hexaploid oat, *Avena sativa* L.

Within cultivated hexaploid oat (*Avena sativa* L.) a wide range of diversity can be observed for quantitative characters (Table 5) such as plant height, which ranged from 30 cm to 200 cm, or in standardized data, from 65 cm less than the checks to 105 cm more than the checks. Wide ranges of diversity also exist for phenological characters. For example, some accessions matured 21 days prior to the average of the Canadian cultivars, while some matured 54 days later. Phenotypic diversity is very obvious when considering qualitative characters (Table 6) of the generative plant parts such as panicle shape (unilateral vs. equilateral) or lemma colour (black, black and white, black and brown, brown and white, grey, reddish brown, tan, white/amber and yellow), which are under the control of a few genes. A character of great practical importance in agriculture and the food industry is the distinction between hulled and hull-less oat. In the PGRC *A. sativa* collection 9,677 accessions (97.7%) were found to be hulled and 284 accessions (2.3%) were hull-less. A phenotypic group of cultivated hexaploid oat which was formerly often distinguished at the species level with the formal name *A. byzantina* C. Koch, or the informal name "red oat" is often mentioned in oat literature. The morphological distinction is mainly based on the separation of the rachilla segment between the first and second floret within the spikelets. In general, the *A. byzantina* group has characteristics of a more primitive type of oat, as indicated by dark coloured lemmas and loose panicles. However, drought resistance is also a characteristic of this group and in the southern United States several cultivars of the *A. byzantina* group have been released and are referred to as red oat. Breeding has created intermediate types between *A. byzantina* and *A. sativa*, which can make morphological distinction between these two types difficult. Within the hulled oats of the PGRC collection, 17.6 % showed the *A. byzantina* and 82.4 % the *A. sativa* floret separation pattern.

The phenotypic differences mentioned above are also reflected in the geographic origin of the accessions. Hull-less, hexaploid oat is frequently described from China and is less common in oat from Europe or other parts of the world. The evolutionary history of hull-less oat is not clear. The *A. byzantina* type oat originates from the Mediterranean area.

3.3.2 Evaluation for disease resistance

For evaluation of disease resistance and quality traits, PGRC cooperated with pathologists at the Cereal Research Centre (CRC) of Agriculture and Agri-Food Canada at Winnipeg. The major disease concerns for Canadian oat growers are crown rust, stem rust and smuts. Since 1998 PGRC supplied germplasm for about 4,500 accessions to pathologists at the CRC. Cooperators at Winnipeg are Drs. J. Chong, T. Fetch and J Gold. The disease resistance screenings focused on the wild hexaploid species of the genus *Avena* and also included landraces of *A. sativa* from

collection missions. This germplasm is the most promising group for detecting new disease resistance genes.

Disease resistance screenings sometimes require access to large amounts of germplasm to be successful in finding resistant germplasm. For oat, this could be demonstrated by the recent screening for stem rust which investigated 6,412 accessions and found two accessions with promising disease resistance (Table 4).

PGRC received from the CRC electronic files with results of disease ratings of the following diseases: Crown rust, 20,152 tests using 34 isolates and bulked pathogen population as inoculum; stem rust, 13,409 tests using four isolates and bulked pathogen populations as inoculum. All data received from Winnipeg is in the process of being integrated in the GRIN-CA Website.

3.3.4 Evaluation for quality

At the CRC, Winnipeg, some quality analysis of PGRC accessions of the *Avena* collection was conducted. PGRC received, so far, results for protein content and oil content of 1,908, resp. 1,917 accessions. For 1,656 accessions data on the percent of hull was received. Oil content and percent of hull were measured using the Near Infrared Reflection Spectroscopy, the protein content was measured using the Kjelldahl method. The data is in process of being integrated into the GRIN-CA Website.

3.3.5 Chromosome counts

PGRC received data of chromosome counts on 7,741 accessions. This cytological information is important for supporting botanical determinations in the oat collection and of critical importance when using the germplasm in breeding efforts. The chromosome counts were mostly conducted on wild species of the genus *Avena*.

3.4 Contacts and cooperation

Cooperation with the University of Saskatchewan (Dr. B. Rossnagel) regarding oat germplasm regeneration and characterization was established. The University planted 500 accessions of oat at their research plots in the years 2000 and 2001 Dr. Rossnagel identified germplasm of interest for his breeding programme.

Recently PGRC responded to seed requests for wild oat germplasm from the United Kingdom (Dr. M. Legget, 1,200 accessions) and Australia (Dr. M. Mackay, 500 accessions). This demonstrates the international recognition of the *Avena* collection at PGRC. The national cooperation with oat breeders at Winnipeg continues and a request for 2,000 accessions of wild oat germplasm was received in December 2002. During the past four years PGRC supplied the CRC, Winnipeg, with about 4,500 accessions of *Avena* germplasm. Due to the regeneration of seeds conducted in this project, PGRC was able fulfill these seed requests.

Dr. Christoph Germeier, the database manager of the European Oat Database, which contains passport and characterization data for the relevant European oat collections, visited Saskatoon from July 20 to August 3, 2000. Thus, the activities conducted by PGRC at Saskatoon are linked to this European network and future cooperation is planned.

The activities of PGRC were presented to the oat breeders and other researchers during the Prairie Registration Recommending Committee Meeting at Edmonton in February 2000. Seven

publications regarding the oat project at PGRC were delivered. A poster was shown at the American Oat Workers Conference at Wilmington, NC, USA, in May 2002 (See Appendix).

The sources for external funding are acknowledged in the publications.

3.5 Deviations from the original work plan

The number of accessions planted by PGRC had to be adapted to the resources available for this project. The characterization and seed cleaning of the field regeneration conducted in 2002 is not yet finalized, but this work will be completed before spring 2003. All data will then be transferred into the Internet.

3.6 Benefits to others

The oat data generated during this project will soon be accessible to the public via Internet. This will allow all users of the PGRC collection very easy access to the data generated during this project. The rejuvenated seeds allows for distribution of germplasm to others. Pathologists and breeders are already making more use of the PGRC collection.

3.5 Additional funding for the project

ADF required PGRC to successfully apply for additional funding for the project. Several companies were approached and the Matching Investment Initiative of Agriculture and Agri-Food Canada contributed to this project. The following additional funds were received up to December 2002 to conduct this project:

(1) Can-Oat Milling Products Inc.: $ 7,500
(2) Emerson Milling Inc.: $ 1,000
(3) Quaker Oats Company of Canada Ltd.: $ 20,000
(4) Popowich Milling Inc.: Value: $ 1,000
(5) Matching Investment Initiative of AAFC: $ 37,500
(6) In kind contribution by UoS, value: $ 16,000

4. Personnel involved in this project

The project involved PGRC staff, summer students and casuals. PGRC hired technicians on a temporarily base, with most funds used to hire summer students and casual helps for conducting filed management, post-harvest characterization and seed cleaning. The list below lists all staff involved in the project. The details for salaries paid by using project funds are given in budget statement in the Appendix.

K. Richards, Research Manager, PGRC
A. Diederichsen, Curator, PGRC
D. Williams, Technician, PGRC, (Leading technician for this project)
Dallas Kessler, Technician, PGRC
P. Breakey, Technician, PGRC
A. (Silvester) McInnes, Technician, PGRC
J. Chong, Plan Pathologist, CRC, Winnipeg
T. Fetch, Plant Pathologist, CRC, Winnipeg
J. Gold, Plant Pathologist, CRC, Winnipeg
L. Knox, summer student

T. Saretskij, casual
L. Wood, technician
J. Yurach, casual
D. Chen, casual
K. Willison, summer student/casual
J. Wilson, summer student
M. Scholten, casual
R. Pilsener, casual

5. Equipment

Not Applicable

6. Project developed materials

The following publications were made base on results from the oat project.

1. Diederichsen, A., D. Kessler and D. Williams (1999): Germplasm of the genus *Avena* at Plant Gene Resources of Canada (PGRC). - Oat Newsletter 45, (http://wheat.pw.usda.gov/ggpages/oatnewsletter/v45/#PGR).
2. Diederichsen, A. and D. Williams (2000): Germplasm of wild and cultivated oat species at Plant Gene Resources of Canada. Oat Newsletter 46, (http://wheat.pw.usda.gov/ggpages/oatnewsletter/v46/#PGR).
3. Diederichsen, A. (in print): The use of Italian *Avena* species for plant breeding from a Canadian perspective. – In: CNR (ed.): Institute for Germplasm 1970-2000, thirty years of conservation of plant genetic resources: perspectives and future developments. Proceedings of a conference at Bari, Italy, 11th of September 2000.
4. Diederichsen, A., E. Timmermans, D. J. Williams, and K. W. Richards (2001): Holdings of *Avena* Germplasm at Plant Gene Resources of Canada and Status of the Collection. Oat Newsletter 47, 35-42. (http://wheat.pw.usda.gov/ggpages/oatnewsletter/v47/#PGR).
5. Diederichsen, A. and D. J. Williams (2002): Agrobotanic characterization of the *Avena sativa* germplasm collection at Plant Gene Resources of Canada. Oat Newsletter 48 (http://wheat.pw.usda.gov/ggpages/oatnewsletter/v48/#PGR).
6. Diederichsen, A., D. J. Williams, Y. B. Fu and K. W. Richards (2002): Active management of the oat (*Avena* L.) Germplasm collection at Plant Gene Resources of Canada. Poster, prepared for Meeting of the North American Oat workers, Wilmington, NC, May 2002.
7. Diederichsen, A. (In Press): Case studies for the use of infraspecific classifications in managing germplasm collections of cultivated plants. Acta Horticulturae.

7. Acknowledgements

Support for the project was acknowledged in publications listed above.

8. Expense statement

A summarized budget statement is attached. Most of the funds received by ADF were used for salaries ($ 59,500). A minor proportion was used for material and supplies ($ 5,500). The detailed budget statement is attached.

Axel Diederichen, Curator, PGRC, Saskatoon, the 23rd of December 2002

Appendix (Tables 1-6, Budget Statement, Poster)

Tab. 1. Composition of the *Avena* L. collections at PGRC (Canada) and USDA (USA)
(Sources: GRIN and GRIN-CA)

Species (*=cultivated species)	Genome	PGRC total	USDA total	PGRC only	USDA only	Duplicates
Diploid species (2n=2x=14)						
A. atlantica Baum et Fedak	?	15	-	15	-	-
* *A. brevis* Roth	A	41	25	26	5	15
A. canariensis Baum, Rajhathy et Sampson	A	45	-	45	-	-
A. clauda Durieu	C	91	-	91	-	-
A. damascena Rajhathy et Baum	A	3	-	3	-	-
A. eriantha Durieu - incl. A. pilosa M. B.	C	132	7	128	3	4
A. hirtula Lag. – incl. *A. prostrata* Ladiz.	A	123	-	123	-	-
* *A. hispanica* Ard. ex Saggi	A	16	-	16	-	-
A. longiglumis Durieu in Duchartre	A	45	13	38	6	7
A. lusitanica (Tab. Mor.) Baum	A	30	-	30	-	-
* *A. nuda* L.	A	19	13	15	9	4
* *A. strigosa* Schreb.	A	134	114	37	14	97
A. ventricosa Bal. ex Coss.	C	5	-	5	-	0
A. wiestii Steudel	A	46	6	45	5	1
Tetraploid specis (2n=4x=28)						
* *A. abyssinica* Hochst.	AB	250	243	189	178	61
A. agadiriana Baum et Fedak	?	14	-	14	-	-
A. barbata Pott ex Link - incl. *A. hirsuta* Moench.	AB	2,025	957	1,471	406	549
A. insularis Ladiz.	AC	1	-	1	-	-
A. macrostachya Bal. ex Coss. et Durieu	?	1	-	1	-	-
A. maroccana Gandog.	AC	34	2	33	1	1
A. matritensis Baum	?	-	-	-	-	-
A. murphyi Ladiz.	AC	2	1	2	1	-
A. vaviloviana (Malz.) Mordv.	AB	135	44	126	35	9
Hexaploid species (2n=6x=42)						
A. fatua L.	ACD	579	1,795	443	1,663	136
A. hybrida Peterm.	ACD	23	1	23	1	-
A. occidentalis Durieu	ACD	62	-	62	-	-
* *A. sativa* L.	ACD	11,622	11,141	2,093	2,035	9,479
A. sterilis L.	ACD	11,461	9,479	4,383	2,526	6,949
A. trichophylla C. Koch	ACD	-	-	-	-	-
Interspecific hybrids (2n=6x=42)						
A. sativa L. x *A. sterilis* L. (= *A. haussknechtii* Nevski)	ACD	1	-	1	-	-
A. sativa L. x *A. fatua* L. (= *A. glabrata* Hussm.)	ACD	1	-	1	-	-
Other interspecific hybrids		254	269	14	29	240
Species not identified (*Avena* spec.)	-	20	337	11	329	9
Total		**27,230**	**24,447**	**9,485**	**7,246**	**17,561**

Table 2. Geographic origin of *A. sativa* in PGRC collection
(only accessions with regeratin and characterization completed)

Country	Accessions
Afghanistan	7
Albania	18
Algeria	8
Argentina	103
Armenia	5
Australia	234
Austria	38
Azerbaijan	6
Belarus	16
Belgium	26
Bolivia	3
Bosnia+Herzegovina	39
Brazil	111
Bulgaria	42
Canada	1431
Chile	6
China	83
Colombia	5
Croatia	31
Cyprus	12
Czech Republic	62
Denmark	32
Ecuador	9
Egypt	2
Estonia	10
Ethiopia	20
Finland	66
Former Soviet Union	14
Former Yugoslavia	7
France	169
Georgia	26
Germany	342
Greece	87
Hungary	61
India	35
Indonesia	1
Iran	5
Ireland	15
Israel	12
Italy	27
Japan	35
Kazakhstan	5
Kenya	6
Korea	10
Kyrgyzstan	4
Latvia	18
Libya	4
Lithuania	13

Table 2. continued

Country	Total
Macedonia	43
Mexico	46
Moldova	9
Mongolia	21
Morocco	22
Mozambique	2
Nepal	1
Netherlands	60
New Zealand	25
North Africa	2
Norway	7
Pakistan	6
Palestine	3
Peru	11
Poland	250
Portugal	12
Romania	51
Russian Federation	533
Slovakia	1
Slovenia	12
South Africa	28
South America	1
Spain	27
Sweden	229
Switzerland	1
Syria	3
Tunisia	6
Turkey	431
Uganda	1
UK	207
Ukraine	90
USA	4665
Uruguay	17
Uzbekistan	4
Western Asia	1
Yugoslavia	197
Zimbabwe	15
Total	10361

Table 3. Number of oat accessions planted for regeneration and characterization by Plant Gene Resources of Canada

Year	Cutivated, hexaploid oat		Other oat species		Total
	Greenhouse	Field	Greenhouse	Field	
1998	6	-	70	-	76
1999	304	4,478	126	552	5,460
2000	10	3,670	468	560	4,708
2001	64	3620	491	999	5,174
2002	120	1,469	217	500	2,306
Sub-total	504	13,237	1,372	2,611	17,724
Total	**13,741**		**3,983**		**17,724**

Table 4. Reaction of *Avena sterilis* L. to inoculation with Stem Rust (*Puccinia graminis*) isolate A67 conducted at the Cereal Research Centre at Winnipeg in 2001

Reaction	Definition	Number of accessions
Very resistant	0-5% stem coverage	1
Resistant	5-10 % stem coverage	1
Moderately resistant	10-20 % stem coverage	20
Moderately susceptible	20-35 % stem coverage	11
Susceptible	>35 % stem coverage	6,385
Total		**6,412**

Table 5. Characterization of quantitative traits in *A. sativa*

(n=number of accessions with observation documented)

Character	Mean	Median	Max	Min	sd	n
Days to heading from emergence relative to average of checks in the same block (weighted mean for checks=49.05 days)	-0.75	-1.00	51.00	-19.00	6.34	**8648**
Days to maturity from emergence relative to the average of checks in the same block (weighted mean for checks=87.57 days)	-1.33	-2.00	54.00	-21.00	6.52	**8319**
Length of leaf blade (cm) relative to the average of checks in the same block (weighted mean for checks=30.82 cm)	-1.68	-1.33	15.00	-18.00	4.73	**8098**
Width of leaf blabe (mm) relative to the average of checks in the same block (weighted mean for checks=15.05 mm)	-1.24	-1.33	13.00	-11.00	2.58	**8095**
Length of panicles relative to the average of checks in the same block (weighted mean for checks=17.34 cm)	1.01	1.00	16.33	-12.33	3.20	**8651**

Table 6. Characterization of qualitative traits in *A. sativa*
(n=number of accessions with observation documented)

Character	Value	Number	Percent
Growth Habit, juvenile	Erect	7265	79.91%
	Intermediate	1569	17.26%
	Prostrate	258	2.84%
	n	**9092**	
Tillering	Few	110	1.83%
	Intermediate	5050	84.19%
	Many	838	13.97%
	n	**5998**	
Leaf Sheath Hairiness	Glabrous	546	59.61%
	Slightly pubescent	213	23.25%
	Moderately pubescent	137	14.96%
	Highly pubescent	20	2.18%
	n	**916**	
Leaf Blade Margin Hairiness	Glabrous	556	53.31%
	Slightly pubescent	244	23.39%
	Moderately pubescent	200	19.18%
	Highly pubescent	43	4.12%
	n	**1043**	
Stem Node Hairiness	Glabrous	641	51.78%
	Slightly pubescent	176	14.22%
	Moderately pubescent	287	23.18%
	Highly pubescent	134	10.82%
	n	**1238**	
Leaves Ligula	Present	8042	99.88%
	Absent	10	0.12%
	n	**8052**	
Panicle Type	Equilateral	7295	79.05%
	Intermediate	1709	18.52%
	Unilateral	224	2.43%
	n	**9228**	
Panicle Erectness	Drooping	1241	13.45%
	Semi erect	6825	73.95%
	Erect	1163	12.60%
	n	**9229**	
Panicle Density	Lax	589	6.38%
	Intermediate	8059	87.34%
	Dense	579	6.28%
	n	**9227**	

Table 6. Continued

Character	Value	Number	Percent
Number of Seeds per Spikelet	1	54	0.55%
	2	8766	88.83%
	3	995	10.08%
	4	52	0.53%
	5	1	0.01%
	n	**9868**	
Lemma Color	Black	106	1.08%
	Black and White	168	1.70%
	Black and Brown	23	0.23%
	Brown	137	1.39%
	Brown and white	291	2.95%
	Grey	98	0.99%
	Red	1009	10.24%
	Tan	5097	51.72%
	White/Amber	138	1.40%
	Yellow	2788	28.29%
	n	**9855**	
Lemma Hairiness	Glabrous	9714	98.45%
	Slightly pubescent	115	1.17%
	Moderately pubescent	36	0.36%
	Highly pubescent	2	0.02%
	n	**9867**	
Lemma Awnedness	No awns	4940	50.08%
	Seldom	3423	34.70%
	Intermediate	1093	11.08%
	One or two awned	181	1.83%
	Two awned	225	2.28%
	More than two awned	3	0.03%
	n	**9865**	
Awn Type	Straight	2883	69.67%
	Subgeniculate	663	16.02%
	Geniculate	592	14.31%
	n	**4138**	
Awn Insertion	1/4 from base	15	0.30%
	1/3 from base	14	0.28%
	Middle of lemma	2776	55.34%
	2/3 from base	2022	40.31%
	Upper 1/4 of lemma	189	3.77%
	n	**5016**	

Table 6. Continued

Character	Value	Number	Percent
Scar Hairiness	Glabrous	5770	58.50%
	Slightly pubescent	3315	33.61%
	Moderately pubescent	751	7.61%
	Highly pubescent	28	0.28%
	n	**9864**	
Spikelet Separtion	Acrofracture	7971	80.65%
	Basifracture	1912	19.35%
		9883	
Kernel Covering	Covered	9660	97.74%
	Naked	223	2.26%
	n	**9883**	